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現場温度圧力条件下における海底下夾炭層への二酸化炭素注入実験
A CO2 injection-experiment with subseafloor coal measures under in-situ pressure and temperature condition

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The release of one-carbon compounds (i.e., CO_2 and CH_4) into the atmosphere due to human activities has been recognized as a major factor causing dramatic climatic change on the Earth. In recent years, the increasing concentrations of greenhouse gases are expected to cause warmer surface temperatures at an accelerating rate and subsequent alternation of ecosystems and biogeochemical cycles. Consequently, a variety of CO_2 disposal options are discussed, including CO_2 Capture and Storage (CCS) followed by injection of CO_2 into deep subseafloor hydrocarbon reservoirs such as coal formations. However, geophysical and geochemical behaviors of high concentration of CO_2 within subseafloor environments, as well as ecological consequence and biogeochemical carbon cycle, remain largely unknown. In this study, we performed a CO_2 injection-experiment using subseafloor bituminous coal samples (Kushiro Coal Mine, Co. Ltd.) under high pressure and temperature condition.

The reaction experiment was performed using a newly developed flow-through geobio-reactor system at the Kochi Institute for Core Sample research, Japan Agency for Marine-Earth Science and Technology (JAMSTEC). The reaction column was prepared from the coal chips (from 1 to 3 cm in diameter) and powdered sandstone, which were packed in a heat-shrinkable tube under anaerobic condition. Anaerobic artificial seawater (ASW) and CO_2 were continuously supplemented into the column for 56 days under the following condition: flow rate of ASW; 0.002 ml/min, flow rate of CO_2; 0.00001 ml/min, pore pressure; 40 MPa, confined pressure; 41 MPa, temperature: 40 degrees C. After the reaction, XRD analysis showed no or very little changes on mineral assemblages of the sandstone, whereas minor carbonate generation was observed by SEM-EDS analysis. The sandstone contained ~10^4 microbial cells/cm^3 after experiments, which was similar to the biomass prior to the experiment. Molecular analysis of the extracted 16S rRNA genes revealed the predominance of spore-forming bacteria (e.g., Lysinibacillus and Bacillus) in the coal samples, which members were also found in the reaction column after the CO_2-injetion experiment. During the reactor operation, we observed increase of dissolved CH_4 concentration up to 186 micro M, whereas total dissolved inorganic carbon in the medium passed through the column decreases compared to the injected amount (e.g., total dissolved inorganic carbon in the medium: 125.6 mM, the injected total dissolved inorganic carbon: 138.38 mM at 56 days). Based on the carbon isotopic composition of DIC, it is most likely that no or very little microbial methanogenesis occurred and the absorbed CH_4 was released from the coal samples during the CO_2-injection experiment.

Keywords: Bio-CCS, Coal, CO2